Climate, land management and future wildlife habitat in the Pacific Northwest

Final project report to the USGS Northwest Climate Science Center

December 13, 2014

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ADMINISTRATIVE

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PUBLIC SUMMARY

Our work addresses the challenges faced by natural resource management planning in the context of climate change. We explore how future climate may interact with management alternatives to shape wildlife habitat across large landscapes. We study habitat for the northern spotted owl in coastal Washington and southwestern Oregon, and habitat for the Greater sage-grouse in southeastern Oregon.

In coastal Washington, the primary threat to owl habitat is likely to be habitat loss as a result of increasing fire and shifts in vegetation with changing climate. These threats may not be fully mitigated with management. In southwest Oregon, increasing fire frequencies under climate change are also likely to pose the greatest threat to owl habitat. Management aimed at constraining fires is needed, but due to the scope of the problem, strategic fuel treatment management will be vital.

In southeast Oregon, some threats to sage-grouse habitat are more manageable than others. Wildfire increased under all climate scenarios. Climatic constraints to sage-grouse from hotter, drier summers cannot be managed, but some effects of climate change may aid the goals of management; for instance, increasing fire frequency can help control juniper expansion. Unfortunately, invasive annual grasses are poised to invade much of the landscape at a rate that we do not have the capacity to manage.

While the task of maintaining and enhancing habitat across large, complicated landscapes in the face of climate change is daunting, our work yields information that is useful in setting management priorities and developing strategies for maintaining habitat and addressing other major goals in all three regions.

TECHNICAL SUMMARY

We originally proposed to conduct an analysis of the possible interactive effects of natural resources management activities and climate change on landscape-scale wildlife habitat within three ecoregions, coastal Washington (CW), southwestern Oregon (SWO), and southeastern Oregon (SEO). We focused on habitat for the Northern Spotted owl (referred to as simply ‘owl’ hereafter) in CW and SWO, and on habitat for the Greater sage-grouse in SEO. We highlight four dimensions of the technical work here: 1) developing information on model starting conditions, 2) modeling management actions in state and transition simulation models (STSMs), 3) estimating likely climate-related changes in vegetation potential and wildfire, 4) model integration and 5) translating STSM results into estimates of wildlife habitat.

1) Starting Conditions/Modeling Strata

For this project, we leveraged many products from the Integrated Landscape Assessment Project (ILAP), including models, maps, tools, and methodology. STSMs from ILAP were used as a baseline, with subsequent improvements based on feedback from managers in the region. Maps of potential vegetation types (PVTs) and current vegetation were also used from ILAP, providing the best available map products to initialize our models. Tools and methodology from ILAP were used to input data layers and allocate initial conditions into each spatial modeling unit for each region (Halofsky et al. 2014a). Synergies with other parallel projects facilitated improvements to this dimension of our work beyond what was directly available from ILAP. These improvements included updates to current vegetation in southeast Oregon so that our initial conditions reflect the effects of recent fires, improvements to wildlife habitat crosswalks, and in SWO, we used an improved version of our potential vegetation map, and an updated current vegetation map, and a new data rollup procedure developed by Washington DNR colleagues to yield better definitions of old forests.

2) Management

The first year of our work was primarily focused on developing management scenarios in all 3 regions (listed in Table 1). This phase focused on developing transition rates for STSMs that would represent current and alternative management strategies for the regions. In the two forested ecoregions, the management types that were considered include silvicultural techniques such as regeneration and partial harvests, and also restoration techniques such as prescribed fire. Management scenarios were implemented within our modeling framework as multipliers applied to transition rates within the cSTSMs. These multipliers were developed through a combination of consulting historic data sources, and also conversations with regional managers and planners.

Table 1: Scenario definitions for each region. * The RegCM3 model is not a global circulation model, but rather a regional climate model, constrained by the ECHAM5 global circulation model.

Region	Management Scenarios	Global Circulation Models
Coastal Washington	No Management Current Management Resilience	Hadley CM3 RegCM3* (ECHAM5)
Southwest Oregon	Current Management Restoration	HadGEM MRI NorESM
Southeast Oregon	No Management Current Management Restoration	HadGEM MRI NorESM

Coastal Washington

Based on interactions with stakeholders in CW, including the Washington Department of Natural Resources (DNR), the Olympic National Forest, and the Nature Conservancy, we ran the cSTSMs under a: 1) no management scenario that was characterized by no active land management; 2) current management scenario that was characterized by current levels of land management, as determined by stakeholder input; and 3) a resilience scenario that was characterized management actions likely to increase ecosystem resilience to changing climate (e.g., thinning from below in dense, homogeneous forests). For comparison, we also ran the cSTSMs under the no management and current management scenarios without climate change effects. Management transitions in the cSTSMs included pre-commercial thinning, thinning from below, salvage harvest, and commercial harvest. Rates of these activities on different land ownerships and management units were determined by stakeholders.

Southwest Oregon

Within SWO, we developed two management scenarios: 1) current management, and 2) an alternative aimed at forest restoration. The restoration scenario was based on the ecological forestry principles outlined by Franklin and Johnson (2012). Additional details specific to ownership classes, and potential vegetation types were determined through outreach to managers and stakeholders, and also discussions stemming from related projects.

We grouped our potential vegetation types into 3 groups: Dry, Moist and Cold, and developed management strategies for each group (for each management-ownership combination). In the moist forests, we set a ‘failure-rate’ for regeneration harvest transitions to indicate the spatial complexity of silvicultural skips and gaps described by Franklin and Johnson. Regeneration harvest rates on public lands were set to allow growing forests enough time to develop the large trees and vertical structure that is conducive to owl habitat (approximately 150+ years). Within the dry forests, management on the public lands emphasized partial harvest techniques to reduce fuel loads to levels where prescribed fire could safely be used to control fuel buildup, for all state classes except for those that were identified as owl habitat. Harvest rates in cold forests were quite low, due partly to the slow forest growth rates indicated by these PVTs, and also because the majority of these forests fell within wilderness areas managed by the US Forest Service, or within Crater Lake National Park.

This restoration strategy would probably provide some economic benefit as a side-effect of the restoration activities. Some economically-driven regeneration harvests would occur on public lands, but extraction of forest products not would be the first priority driving landscape-scale management on public lands.

The current management scenario in SWO was parameterized in a different fashion than in CW. In SWO, we summarized disturbance rates from the LandTrendr dataset (Kennedy et al. 2010) across our management strata (excluding fires represented within the monitoring trends in burn severity dataset, Eidenshink et al. 2007). These modified disturbance summaries were used to estimate annual rates of regeneration and partial harvests. The annual rates were averaged for the years after the Northwest Forest Plan became law (after 1994), and were calculated for each combination of ownership, allocation and PVT.

Southeast Oregon

In the SEO region, we developed three alternative management scenarios, including no management, current management, and a sage-grouse habitat restoration management scenario. The no management scenario assumed that no management treatments occurred on the landscape. For the two scenarios that included active management, treatments included post-fire restoration (herbicide and/or seeding), thinning of shrubs (mechanical and prescribed fire), herbicide/seeding treatments (independent of wildfire), restoration of seeded non-native plantings, and juniper treatments (mechanical and prescribed fire). Treatment rates were specific to each ownership category (state, private, US Fish & Wildlife, and each of four Bureau of Land Management (BLM) districts) and management allocation (priority treatment areas based on core and low-density sage-grouse habitat). Details on management scenarios can be found in Creutzburg et al. (in review, AIMS Environmental Science).

The current management scenario was developed in consultation with managers at the BLM Oregon state office, Oregon Department of State Lands, Oregon Department of Fish and Wildlife, Natural Resources Conservation Service, Oregon Watershed Enhancement Board, and the US Fish & Wildlife Service. Current management activities for state lands and the Hart Mountain Refuge were provided through personal communication with managers. Current management treatments for private lands were provided by the Natural Resources Conservation Service, Oregon Watershed Enhancement Board, and BLM. Current management activities on BLM lands were obtained from the National Fire Plan Operations and Reporting System and Emergency Stabilization and Rehabilitation databases. Using a set of queries designed to estimate the total acreage treated in each of three treatment groups (mechanical juniper treatment, broadcast burning juniper treatment, and shrub thinning) we derived estimates of the number of acres treated in each treatment type. We also obtained the acres of post-fire seeding and weed treatments for a subset of the fires burned in the region from 2005-2013 to estimate the proportion of fire perimeters that are typically treated for post-fire rehabilitation.

The restoration management scenario was developed using current management as a baseline and incorporated feedback from managers in each ownership type. The restoration scenario doubled treatments over levels in the current management scenario for most ownerships (except private lands), and allocated treatments to different types in some cases. In many cases, the restoration scenario used more prescribed fire to control juniper encroachment, and it also modeled treatments that are currently not widely used, such as restoration of seeded crested wheatgrass plantations and prescribed fire to thin shrubs.

3) Climate

Within each ecoregion, we worked with David Conklin (Common Futures) to calibrate and run the MC2 Dynamic Global Vegetation Model (Bachelet et al. 2001), exploring different global circulation model (GCM) projections (listed in Table 1). GCMs for CW were from the World Climate Research Programme's Coupled Model Intercomparison Project phase 3 (CMIP3) multimodel dataset and were run under the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios A2 carbon dioxide emissions scenario (Nakićenović and Swart 2000). GCMs for SWO and SEO were from the newest set of GCM runs, the Coupled Model Intercomparison Project phase 5 (CMIP5) under the Representative Concentration Pathway 8.5 greenhouse gas forcing scenario (Riahi et al. 2011).

4) Model Integration

Results from MC2 were used to convert our STSMs into what we call climate-smart STSMs, or cSTSMs. The goal was to bring information on climate-driven changes to vegetation potential and wildfire regimes into our STSM modeling framework. In our non-climate smart modeling framework, we related each potential vegetation type into a single, independent STSM. This constrained vegetation potential so that it cannot change through time. To incorporate the likely shifts of vegetation potential with climate change, we created our cSTSM by combining and connecting many STSMs to allow shifts among PVTs. For most of our PVTs, the inter-PVT transitions connect post-disturbance classes since the bulk of vegetation-type changes are likely to occur after these inter-PVT transitions are extracted from output from the MC2 biogeography module (one exception to this rule is the xeric shrub-steppe model, described for SEO). The MC2 biogeography vegetation types were related as closely as possible to our PVTs, and annual transition probabilities for each inter-PVT transition were extracted transition from the MC2 output for all timesteps, using the R package MC2toPath.

To illustrate climate-driven changes in fire regimes, we extracted annual fire rates for vegetation types from MC2 model output. These rates are normalized to a baseline average regime, transforming the temporal fire occurrence sequences into temporal multipliers. These multipliers modify effective fire probabilities through time within our cSTSM modeling runs so that they represent the interannual variability and trends contained within the fire data from MC2. These fire trend multipliers were generated for each PVT by calculating changes in the proportion of cells experiencing fire for each PVT at each time step, and normalized to a baseline level. The baseline was extracted from historic model runs for CW, and from the first 20 years of the record for SWO and SEO where we lacked a historic record.

5) Habitat

In order to summarize our cSTSM results to illustrate habitat, we identified which state classes within the overall model were likely to be habitat for the target species in each region. While this dimension of our work stemmed from state-class-habitat crosswalks developed for ILAP, we modified these crosswalks to improve upon them. For detailed tables describing the state-class-habitat relationships that we used, see our compiled results database (available soon at https://www.sciencebase.gov/catalog/item/5006e784e4b0abf7ce733f4d).

Within Southwestern Oregon, we used ArcGIS to extract information about how our spatially explicit state class grid related to a habitat suitability index grid for the Northern Spotted Owl that was developed for monitoring the effectiveness of the Northwest Forest Plan (Davis et al. 2011). This modification to the northern spotted owl crosswalk was informally reviewed by Dr. Davis. While our starting conditions are not perfectly aligned with the habitat suitability index grid, they are adequate to our purposes of describing broad patterns in habitat density and tracking changes through our simulations.

For CW, Anita Morzillo (Oregon State University) refined the vegetation-potential habitat relationships to incorporate habitat quality (high-quality and low-quality habitat). These relationships were further refined with feedback from DNR experts. Each PVT was rated for habitat quality (0 = not habitat, 1 = low quality habitat, or 2 = high quality habitat). Then, for the PVTs rated as low and high quality habitat, habitat ratings were assigned to each structural stage in the state-and-transition model (0 = not habitat, or 1 = habitat).

In SEO, work in collaboration with the SageCon project to map habitat for the greater sage-grouse led us to modify the original ILAP crosswalk for sage-grouse. The habitat mapping project highlighted the role of climate in constraining sage-grouse populations within otherwise-favorable sagebrush steppe vegetation. Our emerging understanding of the direct role of climate in constraining sage-grouse, based on feedback from wildlife biologists, led us to modify the MC2 bioegeography module. We encoded a very simple climate envelope ruleset to enable us to track climatically suitable sage-grouse habitat through time and exclude areas that are too hot and dry during summer months to support sage-grouse populations. We then used the work of Evers (2010) to allocate state classes within the models as habitat or non-habitat.

PURPOSE AND OBJECTIVES

Overall Purpose and Objective

Our original overall objective was to develop and run a set of simulation models that would illustrate the effects of alternative management policies on wildlife habitat for target species, under alternate future climate scenarios. This set would allow us to evaluate whether any of the management alternatives would achieve the goal of habitat maintenance or improvement through time under the changing pressures of climate shifts, and whether any plans were robust across the climates we assessed. An important dimension of this work was that our results would be heard and understood by people directly involved with practical, landscape-scale management planning activities, especially on the public lands, which encompassed the majority of the landscapes that we studied.

The overall objective of developing a suite of simulations that we shared with the management community was met in all three regions. In SWO, in person visits with the Southern Oregon Forest Restoration Collaborative sparked lively and informative discussions about some issues that the climate-smart state and transition models highlighted, especially with respect to the urgency of effective fire management practices. In CW, we worked closely with the Washington Department of Natural Resources and Olympic National Forest to develop accurate current management scenarios and future management scenarios that would yield information on effectiveness of potential future management regimes. In SEO, we integrated with the SageCon project and consulted with managers from many different agencies to construct management scenarios that were accurate and informative.

Even in the cases where our results did not show a clear and obvious successful management option, they highlighted the relative importance of different challenges to landscape-scale habitat management. They were also useful in indicating priorities to consider for the future, either with respect to which threat could best be mitigated with investments in management (e.g., juniper invasion in SEO), or geographic priorities (protecting developing owl habitat near the coast in SWO, and in particular watersheds in CW).

The overall objective of developing an array of simulation models to highlight challenges and tradeoffs involved with natural resource and habitat management as it interacts with climate change was met in all three regions. Some details of the work were modified within each region, as described above in the technical summary, but none of these modifications fundamentally changed the overall objective, and some of them enhanced our project's effectiveness at generating useful and relevant simulation results to compare.

Goals, or procedures curtailed, or reduced:

Utilize output directly from Integrated Scenarios Project,

When we began this project, we hoped to be able to directly use output generated by the Integrated Scenarios Project, also sponsored by the Northwest Climate Science Center. However, we did not make this tight link to their project, because we eventually found that we needed higher spatial resolution, and local calibration of MC2 in order to produce results that would be appropriate to use at the scale of our analysis. The Integrated Scenarios MC2 results are quite appropriate for describing broad trends across several states, but they lack the fine-scale details to illustrate changes in complex terrain, and lack precision to show patterns at the ecoregional scale at which we were working. Instead, we ran MC2 as part of the project for all three study regions. The benefits of this decision are discussed below under "Goals, or procedures expanded or enhanced"

Goals or procedures expanded or enhanced

Improved input data for model initialization

In SWO, our work was extended through collaboration with the BLM to improve our PVT map. We were approached because the BLM needed an improved map of potential vegetation for use in their current draft of their resource management plan. They had identified the vegetation map that we were using as the best option available, but they still wished to see some improvements, and they contracted us to complete the work. This collaboration had two primary positive impacts on our climate science center project. The first was a practical impact on the quality of our science. The improvements to our starting conditions are reflected in our results. The second impact was a positive influence on outreach. Discussions that began during the PVT mapping process evolved into discussions about management priorities for the BLM and USFS for those vegetation types.

Local running and calibration of MC2 within all 3 regions – finer spatial resolution, local calibration.

Because we did not directly use MC2 model results from the Integrated Scenarios project, we were able to work with MC2 ourselves, with assistance from David Conklin. This had the benefit of yielding MC2 results at a finer spatial resolution which allowed for estimating climate-related potential vegetation transitions for high elevation vegetation types in complex terrain (these diminish with coarse spatial resolution). In SEO, we also developed an updated rule set to better distinguish shrub steppe and other rangeland vegetation types, and with David Conklin's assistance, integrated a habitat rule set to incorporate climatic constraints on sage-grouse habitat into the variant of MC2 we used for this project.

New data rollup tool.

Because collaborators within Washington DNR improved upon the ILAP data rollup tool (used for deriving a map of model state classes from potential and current vegetation maps), we were able to improve the definitions of our initial conditions. The original ILAP data rollup tool used a single ruleset to differentiate among structure stages for all types of forest. The new data rollup tool allows for PVT-specific definitions of structure stages. Additionally, the new data rollup tool integrates information from a richer array of vegetation summaries to assign structure stages than the 4 used in the original ILAP data rollup tool.

Scenario Details Modified

In our original proposal, we indicated that we would explore three management scenarios within each ecoregion, and intersect them with three GCM scenarios, resulting in a total of nine sets of simulation runs within each region. Within each region, these specifications were modified to better match with the needs of the stakeholders consulted through outreach activities.

In our proposal, we planned to develop 'local economy' scenarios that would emphasize the landscape's potential to yield economic gains for local communities. Throughout our outreach activities, we found more interest and support in building a single scenario that would emphasize a balance between environmental concerns and potential economic gains. In both Oregon regions, this was named our ‘restoration’ scenario, and in CW, it was named a ‘resilience’ scenario.

In SWO, we did not run ‘no management’ scenarios, but rather confined our analysis to the current, and restoration scenarios. This decision was made partly in the interests of simplicity, but also because our current management scenario shows very little management on federal lands, and so the contrast with a no-management scenario would have been minimal.

GCM choices

Because of the close collaboration with the Washington DNR (as well as additional financial support from them), the climate-related work in that region was tuned to their preferences. Because the funding for working with these models was only available for Washington, the Oregon regions used a different set of GCMs that were already formatted appropriately for MC2.

ORGANIZATION AND APPROACH

Our work was organized geographically, with one person primarily responsible for all tasks within each region. Jessica Halofsky completed the work in CW, Emilie Henderson worked within SWO, and Megan Creutzburg worked within SEO.

Within each region, Anita Morzillo provided feedback on wildlife crosswalks, and contractor David Conklin assisted with calibration and running of MC2.

The list of tasks that were completed across all regions include:

1. Design of management scenarios.
2. Model expected vegetation and fire regime changes under climate change with MC2.
3. Integrate MC2 results with cSTSMs
4. Model management interaction of climate-related changes from step 2 with management scenarios in step 1.
5. Summarize, graph and map results from step 4 with respect to wildlife habitat, and regional summaries of interest.

Coastal Washington

For CW, work was done in the first year of the project to meet requirement of funding from the Washington DNR. The CW kickoff meeting was held in January 2013, and modeling work was completed by the end of the 2013. The project benefitted from close coordination with DNR scientists and managers.

Southwest and Southeast Oregon

For both Oregon regions, our primary focus was on step 1 for the first year. During this year, our work dovetailed with other, related projects which facilitated the building of the relationships that were needed to gain feedback about how to design management scenarios.

During the second year, we completed tasks 2 – 5. David Conklin assisted with calibrating and running MC2 for three climate scenarios in the region and integrating those MC2 results within the STSM framework to build our cSTSM.

PROJECT RESULTS

Coastal Washington

Potential Vegetation

The cSTSM results for CW suggest that a decline in the area of the western hemlock vegetation type is likely, with a more dramatic decline (nearly 50%) projected under the hot and dry Hadley scenario (Figure 1). Under the RegCM3 scenario, a decline in the area of the Sitka spruce vegetation type is also projected. These types were replaced by Douglas-fir dominated vegetation types that are adapted to drier conditions: dry grand fir and dry Douglas-fir/grand fir.

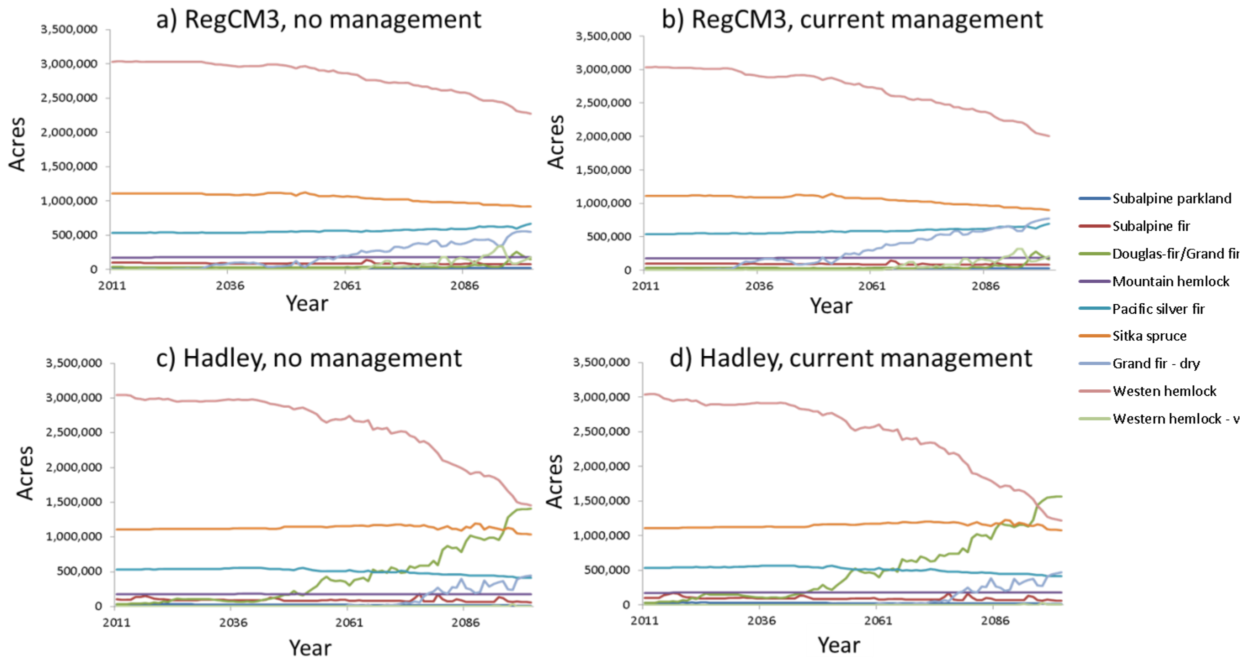

Figure 1: Future changes in area of potential vegetation types in the Washington coast range, as modeled by climate-informed state-and-transition models, under the a) RegCM3, no management; b) RegCM3, current management; c) Hadley, no management; and d) Hadley, current management scenarios.

Effects of Management

Under both climate scenarios, vegetation shifts were greater with management (Figure 1). This is likely because variable retention harvest and regeneration harvest on state and private industrial lands create the open, post-disturbance conditions that we modeled as being more susceptible to shifts in vegetation type under changing climate. Management also resulted in a decrease in the area of forest in larger size classes and an increase in the area in smaller size classes (results not shown), since variable retention harvest and regeneration harvest remove large trees.

Although thinning can facilitate development of late-successional forest habitat conditions by increasing species and structural diversity (Carey and Wilson 2001), this structural detail is not reflected in the cSTSMs. For example, a multi-storied (>1 canopy layer), closed canopy condition (>60% canopy cover) within a given diameter range could represent a structurally diverse or homogenous condition. Thus, the resilience scenario, characterized by increased levels of thinning on national forest lands, and current levels of management on DNR lands, did not mitigate impacts of climate change in the CW model simulations (results not shown).

Rather, increased levels of current management on state lands resulted in increased vegetation change, rather than decreased vegetation change, under changing climate. Although not modeled, we believe planting could mitigate some of the change in vegetation we observed. Whether planting of currently climatically suitable species will result in the desired productivity of future forests is less certain.

Owl Habitat

The refined vegetation-owl habitat relationships allowed us to determine the potential effects of climate change and management on potential owl habitat (Figure 2). Without climate change or management, area of high-quality potential owl habitat increased or remained approximately the same. However, under both climate change and management scenarios, area of high quality potential owl habitat declined steadily through the century. These results suggest that climate change will result in vegetation shifts away from types that are typically associated with high-quality potential owl habitat, and that current management will not mitigate those shifts, but rather expedite them. Results suggest that the probability of maintaining current levels of high-quality potential owl habitat by 2100 are low (less than 20%) in many watersheds of the CW (Figure 3a). Reducing habitat goals to 75% of current levels increased the likelihood of maintaining this lower threshold into the future (Figure 3b).

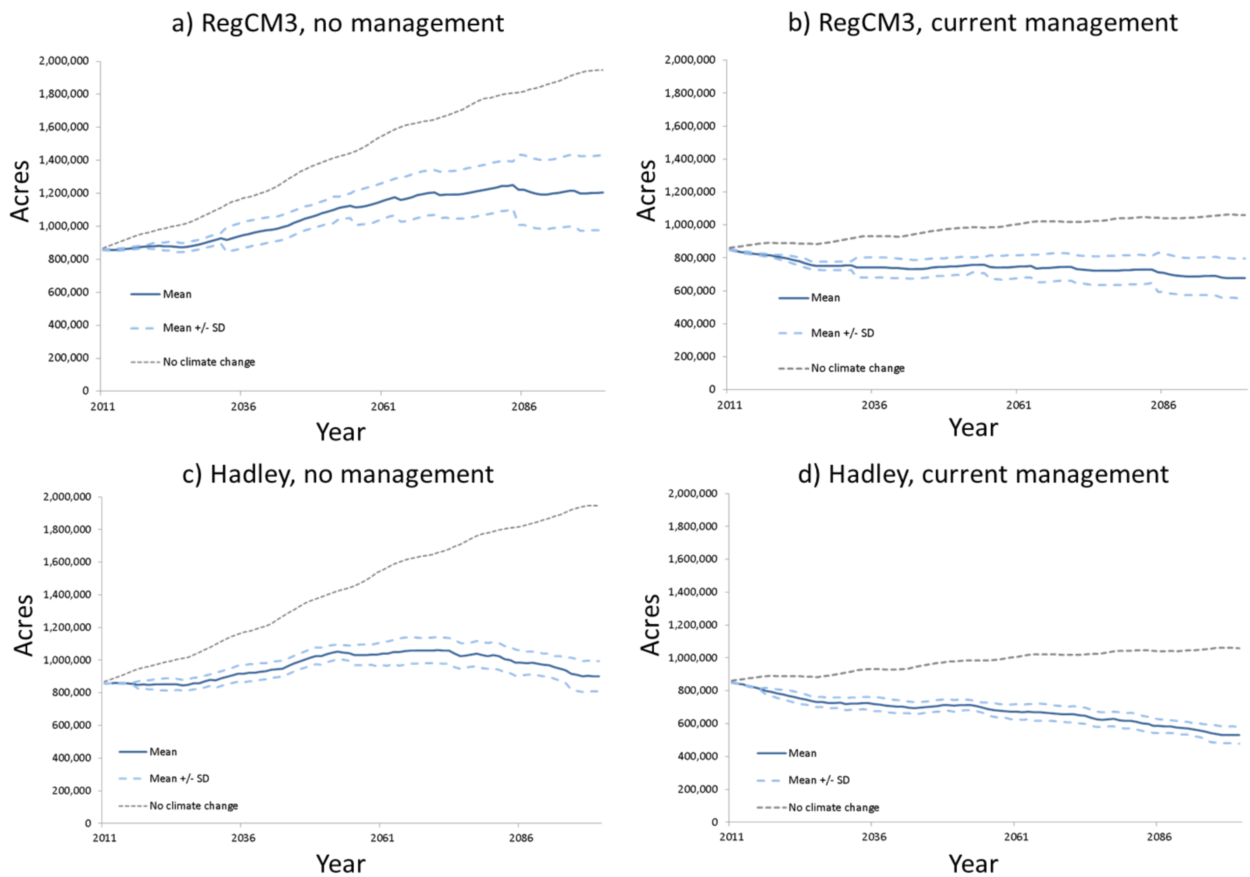

Figure 2: Area of high-quality potential northern spotted owl habitat under the a) RegCM3, no management; b) RegCM3, current management; c) Hadley, no management; and d) Hadley, current management scenarios. Dark blue solid lines represent mean area of high-quality potential habitat across 60 Monte Carlo simulations, and light blue dotted lines represent the mean plus and minus one standard deviation. Gray dotted lines represent high-quality potential habitat trends when climate change is not considered in the model simulations.

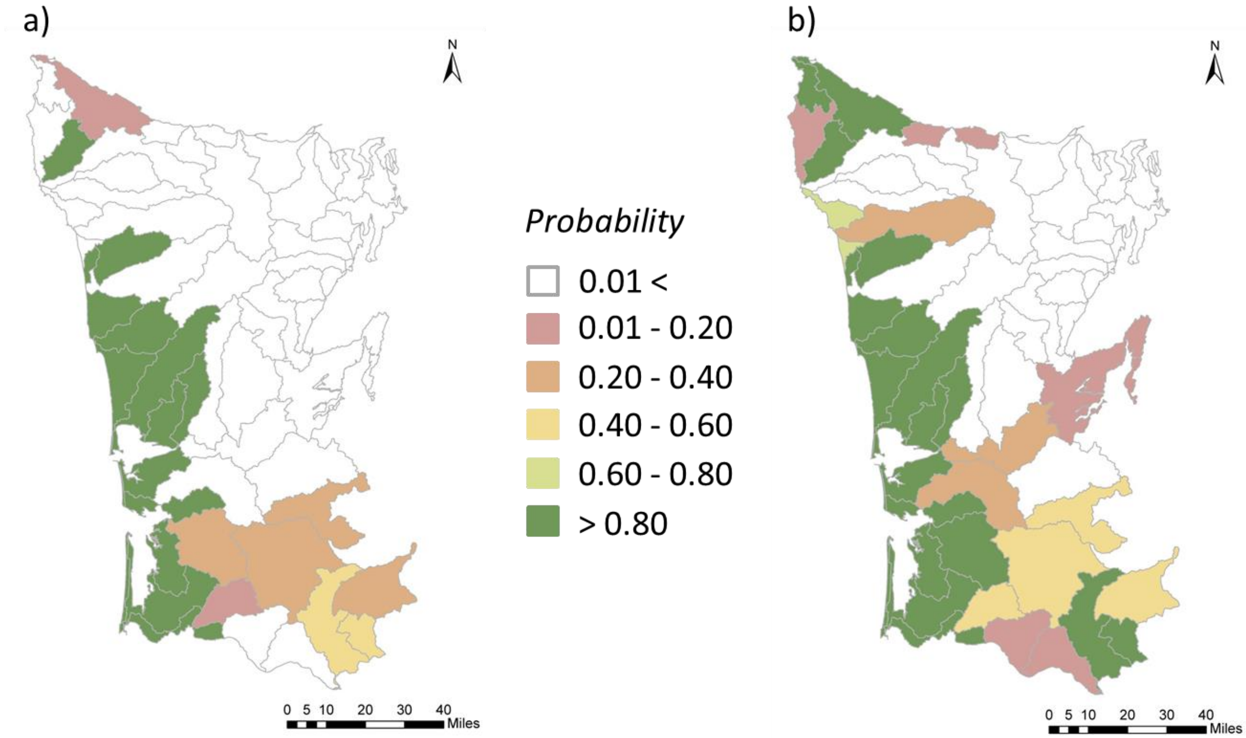

Figure 3: The probability of a watershed maintaining or exceeding current potential northern spotted owl habitat levels (a) and 75% of current habitat levels (b) in 2100. These probabilities were calculated using a metric called the Probability of Exceedance (Halofsky et al., 2014b) using all 60 total Monte Carlo simulations of the cSTSMs combining output from both the RegCM3 and Hadley climate scenarios, for the current management scenario.

Southwest Oregon

Potential vegetation

Potential vegetation shifted through time in SWO. The most pronounced changes happened to the moist tanoak, and intermediate western hemlock forest. Moist tanoak expanded greatly for all 3 climate change scenarios (Figure 4). Its expansion was the greatest under the HadGEM climate change scenario (Figure 4a). Intermediate western hemlock also declined across all climate scenarios, but the timing of its decline varied from scenario to scenario. Its decline was most gradual within the MRI model (Figure 4b), and most abrupt within the NorESM model (Figure 4c). Shifts in the relative abundance of the other PVTs also occurred, but these were minor in comparison with the changes in the abundance of the moist tanoak and intermediate western hemlock forests.

Wildfire

Fire regimes also shifted dramatically under climate change (Figure 5). Changes in fire regimes were most severe under the NorESM climate change scenario. Management had very little effect on the relative dominance of stand replacing, mixed severity, and nonlethal fire within the fire regimes. In the early simulated years, the relative dominance of each type of fire was practically identical for the two management scenarios, but the restoration scenario had an apparently negative effect on fire severity during the later years (Figure 5).

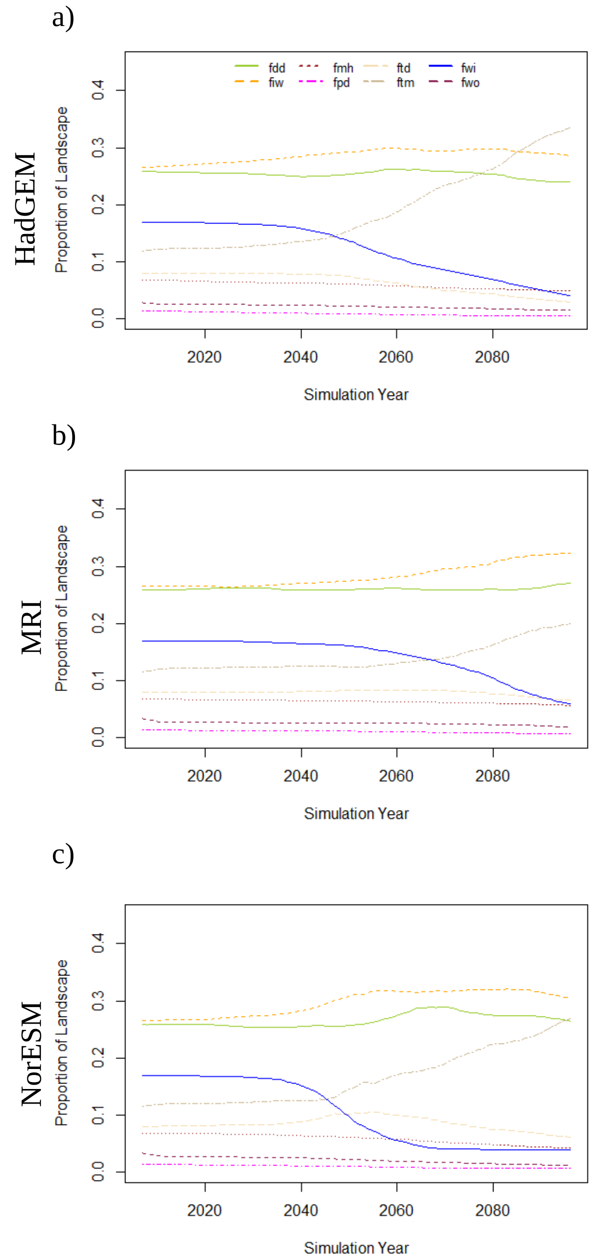

Figure 4: Representation of potential vegetation types across Southwest Oregon Study area, for the “current management” scenario only. Legend for all figures is in panel ‘a’. fdd = “Dry Douglas-fir forest”,fiw = “Intermediate White fir forest”, fmh = “Mountain Hemlock forest”, ftd = “Dry Tanoak forest”, ftm = “Moist Tanoak forest”, fwi = “Intermediate Western Hemlock”, fwo = “White oak”.

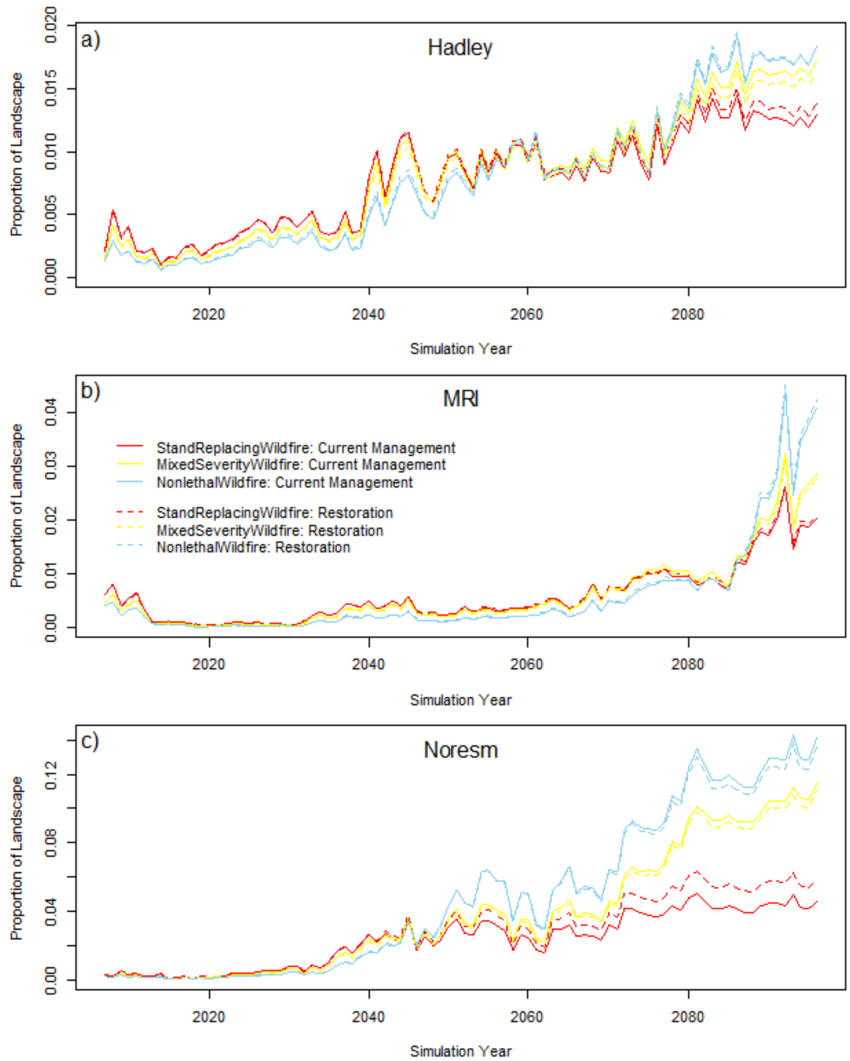

Figure 5: Southwest Oregon wildfire trends for management, climate scenarios. Note that Y axis differs among the panels.

Owl Habitat

In SWO, our restoration scenario did not show a strong effect on the amount of owl habitat through the simulation, in comparison with the trajectories projected by the current management scenario (Figure 6). Climate had a much stronger effect. In general, the restoration scenario yielded reductions in the proportion of the landscape comprised of owl habitat. The difference between the restoration and current management scenarios was greatest in the middle of the simulation years, when owl habitat reached its peak. The dates of this peak changed from climate scenario to climate scenario.

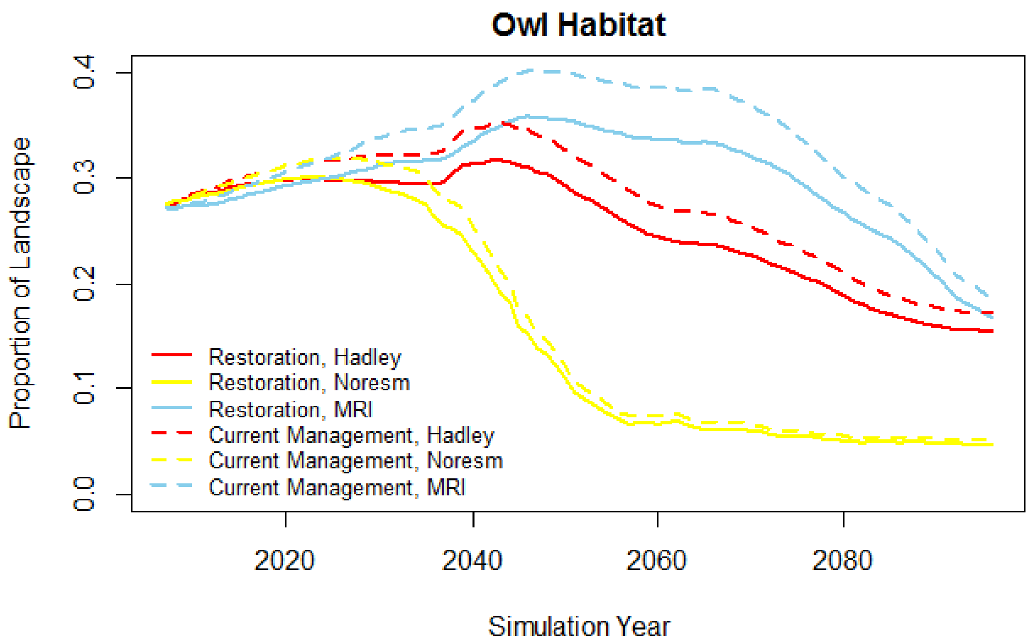

Figure 6: Proportion of modeled landscape comprised of northern spotted owl habitat through time, by scenario.

The spatial distribution of owl habitat shifted through time (Figure 7). At the start of the modeling run (2007, Figure 7a,e,j), owl habitat density was greatest within northeast, and the federal lands of the north-central part of the region. By simulation-year 2050 (Figure 7d,h,k), the spatial location that had the greatest density of owl habitat shifted to the west for the HadGEM and MRI climate scenarios. This shift is a result of owl habitat losses due to fire in the areas that currently have the highest habitat density, and gains in owl habitat due to growth of the currently-younger forests in the western part of the region. This pattern is not consistent among the climate models. The NorESM climate model (Figure 7i,j,k,l), shows consistent, drastic reductions to owl habitat throughout all timesteps. This is probably driven by the extreme levels of fire in this model. Across all three climate scenarios, fire caused the greatest direct losses to owl habitat area (illustrated for restoration management, HadGEM climate scenario in Figure 8).

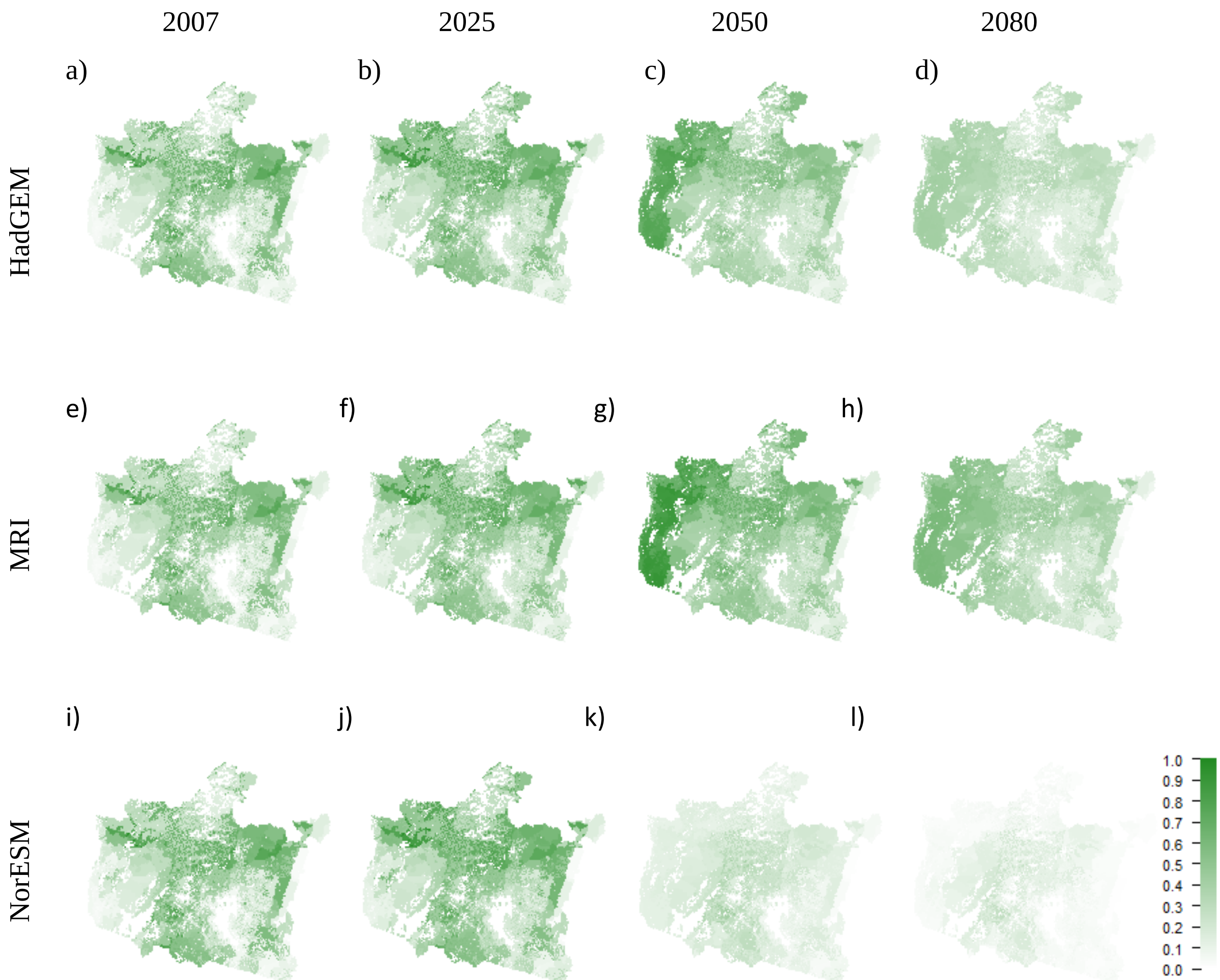

Figure 7: Spatial depictions of owl habitat across region for 4 timesteps, current management scenario. Maps show results applied to spatial depiction of modeling strata. The color ramp indicates the proportion of each modeling stratum that is comprised of owl habitat. The maps can be interpreted as illustrations of owl habitat density. The legend in the lower right corner of the figure applies to all maps shown.

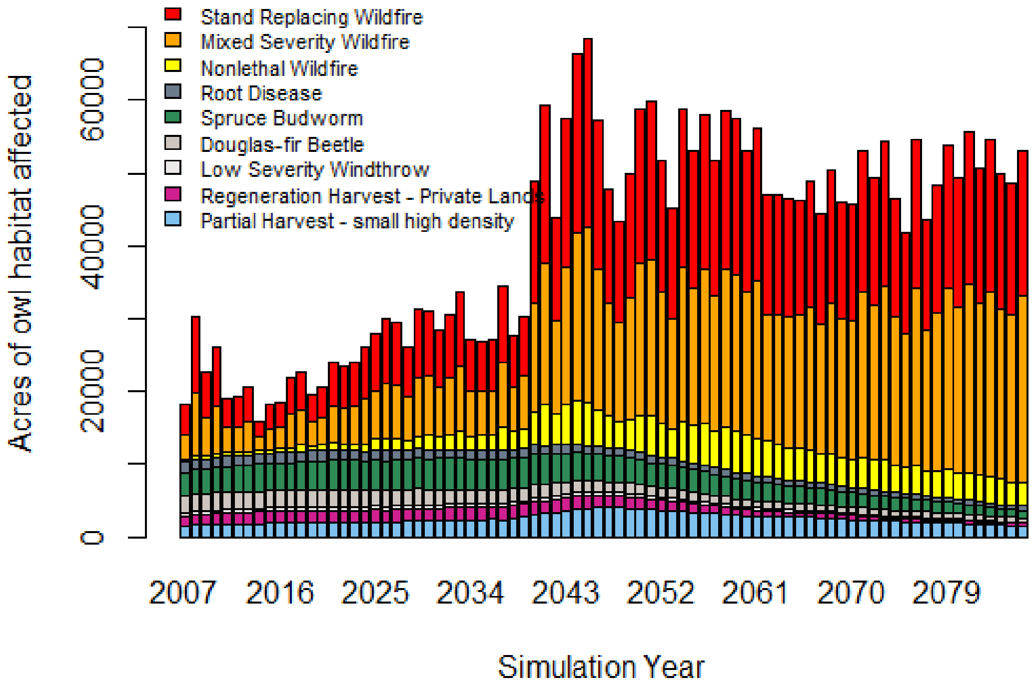

Figure 8: Area of owl habitat lost due to transitions within the restoration management scenario, under the HadGEM climate scenario.

Southeast Oregon

Potential Vegetation Types

Under continuing current climate, PVTs remain unchanged over time, with 47% of the landscape in warm-dry shrub steppe, 22% in cool-moist shrub steppe, 15% in xeric shrub steppe (shrub steppe that is climatically unsuitable for sage-grouse), and 17% in forested types (Figure 9). Under all three climate change scenarios, cSTSM projections indicate increases in cool-moist shrub steppe and declining warm-dry shrub steppe by the end of the century. The extent of xeric shrub steppe fluctuated widely due to interannual variability in summer temperature and precipitation projections. By the end of the century, the extent of xeric shrub steppe declined to nearly zero under NorESM, declined to 4% of the landscape under MRI, and increased to 27% under HadGEM. All climate change scenarios projected relatively minor changes in forested extent.

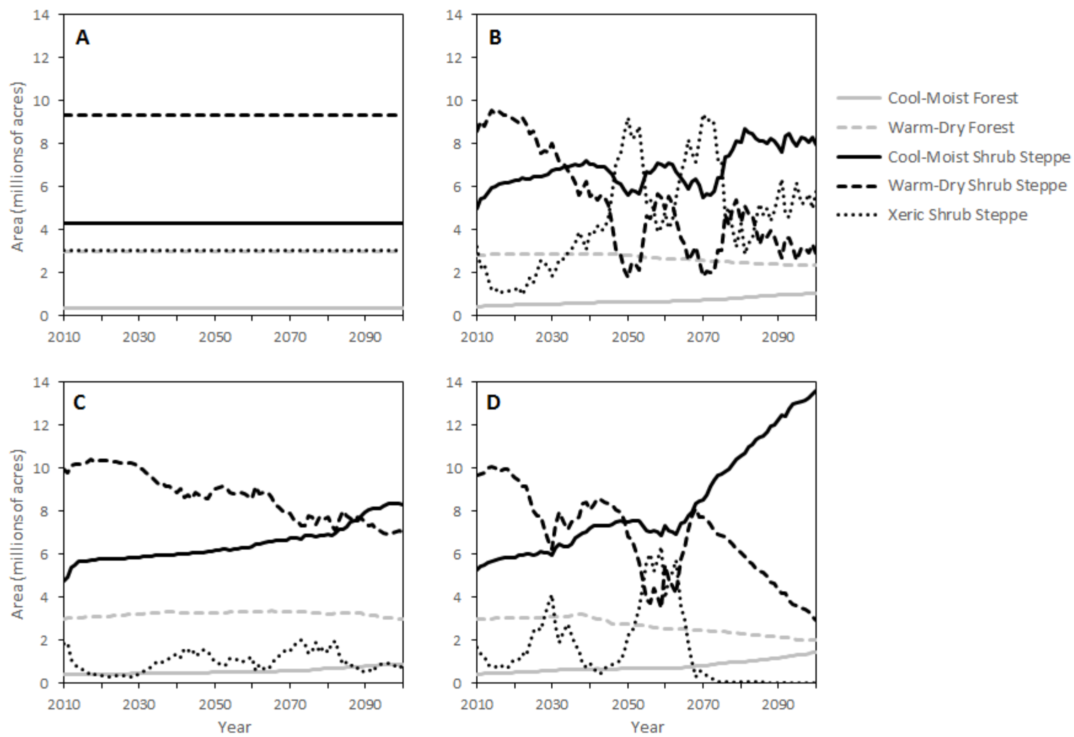

Figure 9: Projected trends in potential vegetation types over time under current climate (A) and three scenarios of climate change, including HadGEM (B), MRI (C), and NorESM (D). Projections are shown without active management (no management scenario).

Wildfire

Wildfire increased over the course of the simulation in all scenarios (Figure 10). Early in the century, the average area burned in wildfires was roughly 200,000 acres across all climate scenarios. Under current climate, wildfire increased by 26% due to increases in exotic annual grass state classes. Under climate change, the area burned doubled under the NorESM climate scenario and increased by 4x under the HadGEM and MRI climate scenarios.

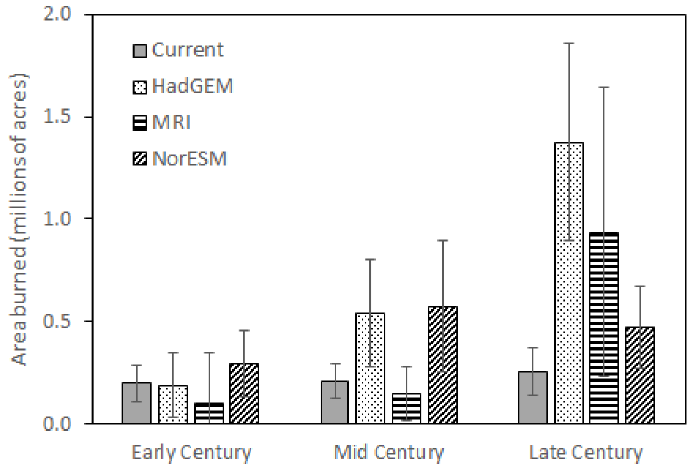

Figure 10: Average annual area burned in wildfires (±1SD) in early century (2011-2030), mid-century (2046-2065) and late century (2081-2100) projections. Projections are shown without active management (no management scenario).

Vegetation Composition

Vegetation composition across the landscape shifted rapidly under all climate scenarios without active management. The initial landscape was dominated by semi-degraded shrub steppe, where the herbaceous layer is partially dominated by exotic species. Under all scenarios, semi-degraded shrub steppe declined rapidly and was replaced by exotic shrub steppe in the first several decades of the simulations (Figure 11). Threshold woodlands (phase I juniper) occupied 1.8 million acres at the beginning of the simulations and declined slowly as they converted to woodlands (phases II and III) over the course of the simulation. Native shrub steppe declined to roughly one third of its initial extent, while forested areas and seeded non-native shrub steppe remained stable throughout the century. Under all three climate change scenarios, exotic grass increased in the first several decades of the simulations but reached lower levels by the end of the century than under current climate. Juniper woodlands also increased under all climate change scenarios but reached lower levels than under current climate.

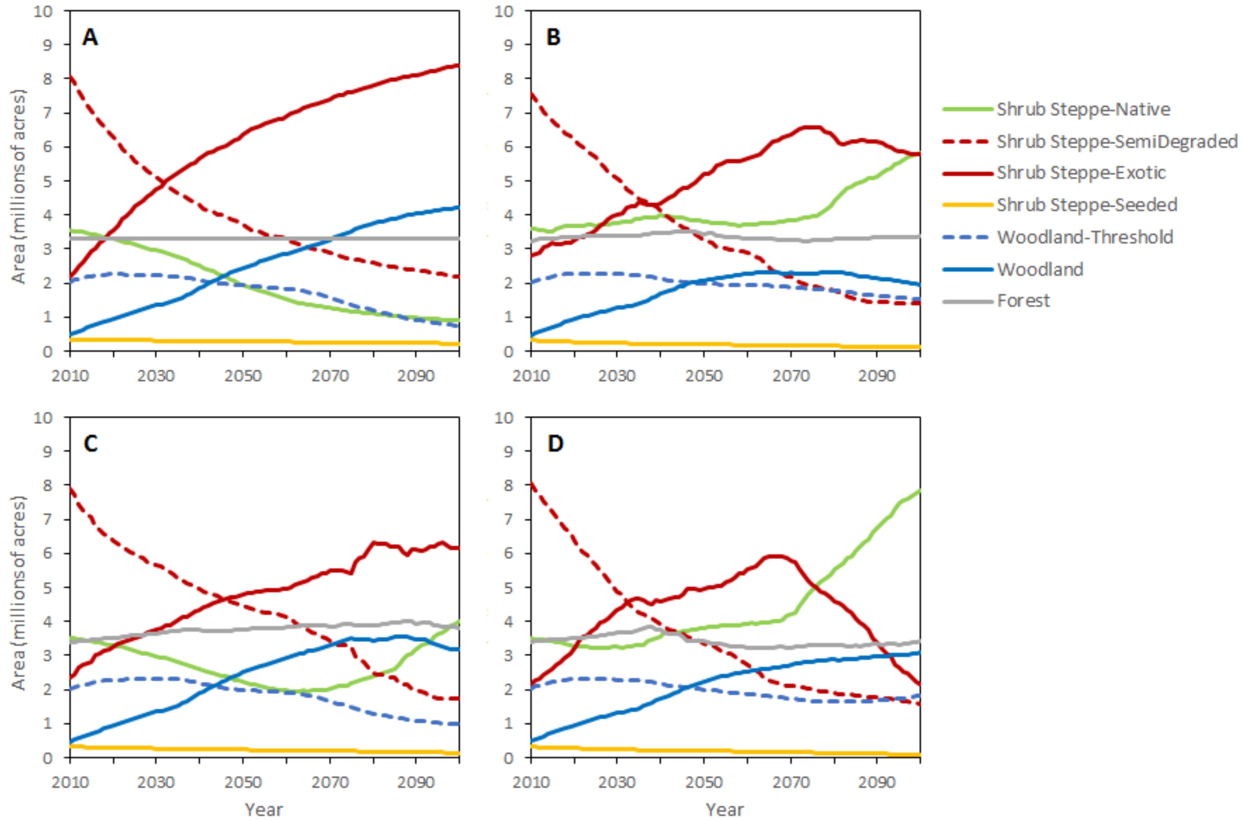

Figure 11: Shifts in vegetation composition (groups of state classes within the climate-informed state-and-transition simulation model) over time under continuing current climate (A), and the HadGEM (B), MRI (C), and NorESM (D) climate change scenarios. Projections are shown without active management (no management scenario).

Management Scenarios

Management activities varied in their capacity to maintain desired vegetation composition. Treatments to control exotic grass were mostly ineffective in reducing the amount of exotic grass on the landscape (Figure 12). Juniper treatments, in contrast, slowed woodland expansion substantially compared to no management. Current management treatments reduced juniper by an average of 850,000 acres by the end of the century compared to no management, and the restoration scenario reduced juniper woodlands by 1.6 million acres. However, juniper still increased over time under all climate-management scenarios.

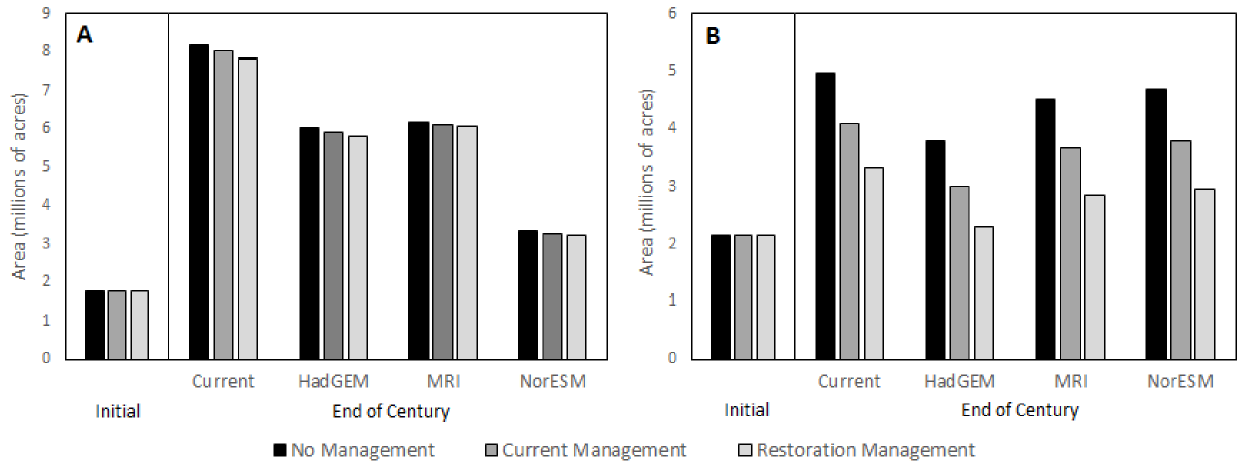

Figure 12: Projections of exotic grass (A) and juniper (phase I, II and III woodlands) (B) under four climate scenarios and three management scenarios, shown in shades of gray. Results are summarized across the entire eastern Oregon study area. The left panel in each graph shows the initial mapped landscape conditions and the middle-right panels show projected average future conditions at the end of the century (2081 – 2100).

Sage-Grouse Habitat

Projected potential sage-grouse habitat declined in all scenarios through mid-century (Figure 13). Under current climate, potential sage-grouse habitat declined to less than half of its current extent. The three climate change scenarios showed similar trends to current climate for the first half of the simulations but ended with a higher overall level of potential habitat. The current management scenario increased potential sage-grouse habitat by 600,000-850,000 acres by the end of the century, depending on the climate scenario, relative to no management. The restoration management scenario increased the area of potential sage-grouse habitat by 1.1 million – 1.8 million acres by the end of the century, relative to no management.

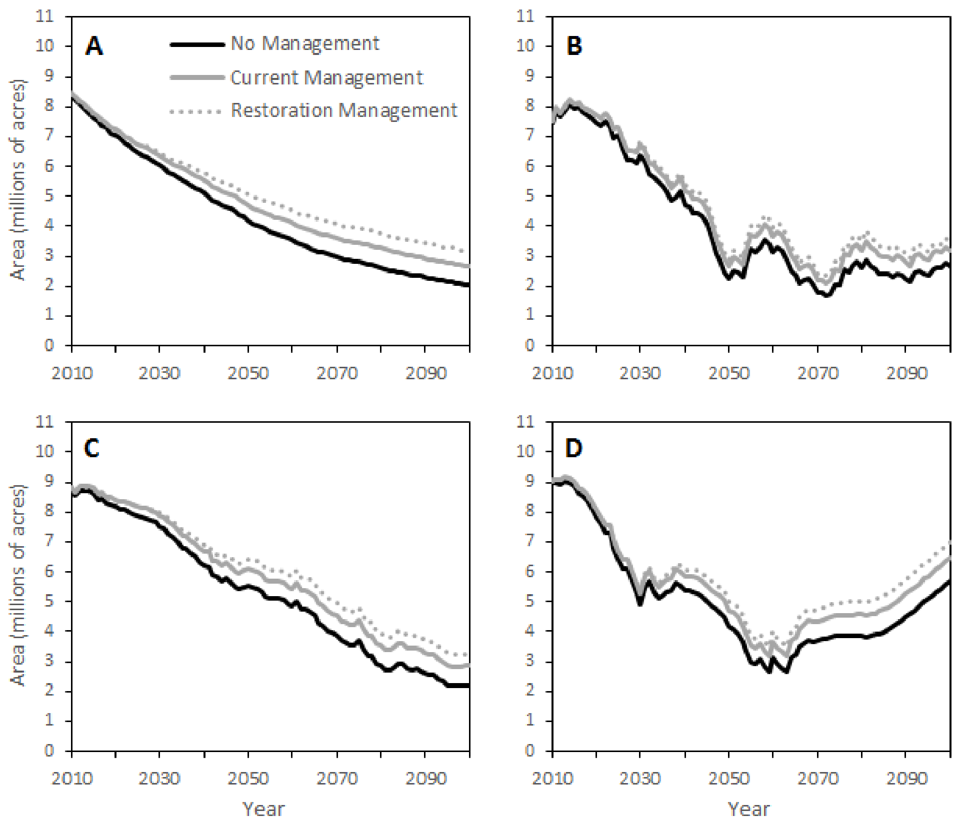

Figure 13: Projected potential sage-grouse habitat under current climate (A), and HadGEM (B), MRI (C), and NorESM (D) climate change scenarios. Line type depicts each of three management scenarios, and results are summarized across the entire eastern Oregon study area.

ANALYSIS AND FINDINGS

Coastal Washington

MC2 simulation results suggest that, under both climate scenarios, climatically suitable zones for alpine, subalpine parkland, mountain hemlock and subalpine fir will shrink by the end of the century. The climatically-suitable area for Sitka spruce also declined under both scenarios, particularly under the RegCM3 scenario. Under the hot and dry Hadley scenario, the area that was climatically suitable for cool mixed forest along the coast expanded, as did areas with climatic conditions suitable for temperate needleleaf forest across the Peninsula. These expansions corresponded with declines in areas that were suitable for the historically dominant vegetation types. The cool mixed forest vegetation type is characterized by both evergreen and deciduous species, suggesting that the deciduous hardwood component in coastal forests may increase in the future. Hardwood species that may increase in abundance include red alder, bigleaf maple, and vine maple (Halofsky et al. 2011). Fire frequency increased under the Hadley scenario, with a fire return interval of 54 years (compared to 208 years for the historical period), which along with drier summer conditions, led to the expansion of the temperate needleleaf forest type. The range expansion of this vegetation type suggests that fire- and drought-tolerant species, such as Douglas-fir, lodgepole pine, and western white pine, will become more abundant (Halofsky et al. 2011).

Under the hot and wet RegCM3 scenario, there was expansion of climatically-suitable habitat for temperate warm mixed forest along the coast, and expansion of climatically-suitable habitat for cool mixed forest inland. The mixed forest vegetation types are characterized by both evergreen and deciduous species, again suggesting that the deciduous hardwood component in forests of CW may increase in the future, particularly if precipitation increases, as it does under the RegCM3 scenario. Topographic patterns of vegetation were more distinct under the RegCM3 regional climate model simulations, with distinct Pacific silver fir and some western hemlock remaining in the future. The fire return interval under the RegCM3 model was 71 years, again suggesting increased fire frequency in the future.

Southwest Oregon

Shifts in potential vegetation across SWO could be pronounced, especially with respect to the expansion of mixed, evergreen-broadleaf forests. This finding is consistent with results from the Integrated Scenarios project across much broader scales, which predict, from MC2 modeling efforts, that mixed forests will expand across the coast ranges of Oregon and California (data can be viewed at: http://databasin.org/galleries/ffc826d1237a46288684266f95a2c41a). In particular, they illustrate expansion in the vegetation type that MC2 names ‘subtropical mixed forest’. In our modeling effort, we translate this type to our moist tanoak potential vegetation type, as its spatial extent within the region modeled by Integrated Scenarios fits within a zone containing a fair amount of moist tanoak, and also redwood forests. Future work to better assess this choice, perhaps introducing a new STSM to represent a new, warmer, mixed forest type could be useful for improving the realism of our models.

Wildfire

Our results confirm that the threat of wildfire is of primary concern in the forests of southwestern Oregon. Even in recent years, wildfire has been cited as the primary threat to owl habitat (not to mention other forest values) in the region (Davis et al. 2011). Climate change will only exacerbate the problem. Although the nature of the problem is clear, the magnitude of the expected changes is not. By our estimates, future annual area burned with stand replacing wildfire under the NorESM climate scenario could be twice that burned under the MRI climate scenario. The differences among climate scenarios are even more pronounced for nonlethal and mixed severity fire. This pattern of high uncertainty with respect to future fire regimes is consistent with other work (Abatzoglou et al. 2014).

Our restoration management scenario does not appear to mitigate wildfire risk in the near-term, and appears to exacerbate fire severity in the long-term relative to current management. However, it is possible that this pessimistic result may partly reflect an artifact that stems from our aspatial modeling methods (see 'Model Limitations' segment below). It would be worthwhile to study whether the use of restoration forestry could curtail wildfire spread across this landscape, working within in a spatially explicit modeling framework.

Owl habitat and management

Our restoration scenario noticeably reduced owl habitat across the landscape in comparison with the current management scenario. This is unsurprising as the silvicultural treatments aimed at reducing the hazard of severe fire also constrain forest structural complexity. Although we did not directly treat current owl habitat in the public lands in our restoration scenario, we did allow for fuel treatments in younger forests that might have otherwise grown into owl habitat. Thus, structurally complex owl habitat lost due to wildfire is not replaced by younger growing forests as effectively under the restoration scenario as it is under current management. However, these results should be considered with caution because they are highly confounded with the effects of wildfire. If strategically placed fuel treatments can effectively reduce fire spread, then it might still be possible for restoration forestry improve the prospects for future owl habitat. Fire is a much greater threat to owl habitat than is management. Modeling this spatial feedback between management, fire and owl habitat will be the next crucial component in evaluating whether forest restoration might achieve the goal of reducing owl habitat losses by constraining losses due to wildfire.

Southeast Oregon

Potential Vegetation Types

Projected PVT extents diverge substantially from current climate under the three climate change scenarios. Warm-dry and cool-moist shrub steppe are the only PVTs modeled in this study that provide suitable habitat for sage-grouse, as it is a sagebrush obligate species, and these PVTs are key to their persistence. Although warm-dry shrub steppe dominated the initial landscape, cool-moist shrub steppe increased and surpassed the extent of warm-dry shrub steppe in all three climate change scenarios. This expansion of cool-moist shrub steppe is due to two major factors: increases in total annual precipitation in some climate change scenarios, and heightened wildfire frequency, particularly in the warm-dry shrub steppe vegetation type, opening up site potential for conversion to cool-moist shrub steppe. Projections of xeric shrub steppe, distinguished by hot and dry summer conditions which are unfavorable for sage-grouse, were highly variable among climate scenarios. This variability among the climate models highlights the high level of uncertainty in future summer conditions, which could potentially constrain future sage-grouse populations. In our simulations, no major novel vegetation types were introduced into the study area under climate change, although small areas of C4 (warm-season) grasslands and semi-desert shrublands (shrublands without a significant grass component) were present at low levels in some years.

Wildfire

In recent years, large wildfires have burned across much of southeastern Oregon, such as the Miller Homestead, Holloway and Long Draw fires of 2012 that burned over 1.6 million acres of the SEO study area. Our projections indicate a substantial increase in wildfire with climate change, with an average of 1 million or more acres per year burned in wildfires under the HadGEM and MRI climate change scenarios at the end of the century, and many individual years likely to surpass the 1.6 million acres of burned area experienced in 2012. The increasing prevalence of exotic grasses made a small contribution to this pattern; however compositional changes were minor relative to the changing fuels and fire weather simulated in MC2 under climate change, resulting in 2-4 times more fire than current levels. Wildfire can have both positive and negative ecological effects in these rangelands; wildfire is an important part of the natural shrub steppe vegetation dynamics and can aid in controlling juniper expansion, but it can also promote exotic grass invasion and remove shrubs that are essential for sage-grouse populations.

Vegetation Composition

The current landscape in SEO is dominated by semi-degraded shrub steppe, which contains partial dominance by both native and invasive grasses. These semi-degraded state classes are at high risk of rapid conversion to exotic dominance through wildfire (primarily) and the interaction of grazing-related degradation with wildfire and drought disturbances. Once shrub steppe transitions to an exotic-dominated system, the wildfire frequency further increases and the area becomes increasingly poor habitat for sage-grouse. Surprisingly, although exotic grass increased under all scenarios, projections under the three climate change scenarios contained lower levels of exotic grass compared to current climate. This is due to the conversion of warm-dry to cool-moist shrub steppe PVTs as a result of increasing precipitation and wildfire frequency. Because the cool-moist shrub steppe STSM contains higher resilience to exotic grass invasion, the herbaceous layer can recover to native species in a relatively short time frame after it transitions to the cool-moist shrub steppe PVT.

Juniper also expanded across SEO without management treatments. Juniper trees provide perching sites for predators, and sage-grouse tend to avoid areas that have been encroached by juniper trees. Juniper woodlands are only modeled in the cool-moist shrub steppe PVT, as the warm-dry shrub steppe PVT is too dry to support juniper. Therefore, the extent of juniper is closely related to the cool-moist PVT extent, and potential for juniper encroachment increases as the cool-moist PVT extent expands. Projections of juniper woodlands are also closely related to the wildfire frequency, since juniper trees are intolerant of fire. Therefore climate change had two opposing effects on juniper encroachment: it increased the area that is climatically suitable for cool-moist shrub steppe and juniper encroachment, but it also reduced juniper woodlands within that climatically suitable area as because they were removed in wildfires.

Management Scenarios

The management scenarios considered in this study were developed to compare no actions, current practices, and a more intensive restoration scenario designed to improve sage-grouse habitat. We worked extensively with land managers to develop our management scenarios, particularly to accurately represent current management treatment levels. Our model projections indicated that management treatments were generally effective in controlling juniper encroachment, although they needed to be implemented at higher than current levels to constrain juniper encroachment at or below current levels. In contrast, post-fire rehabilitation of exotic grass infestations was largely unsuccessful in warm-dry environments where exotic species are most problematic. Current levels of management treatments were not able to counter the threats of exotic grass and juniper encroachment, but a restoration scenario with greater levels of juniper treatments was effective in maintaining woodland encroachment near current levels in priority treatment areas. Due to the combination of exotic grass invasion, woodland encroachment, wildfire, and summer drought stress, potential sage-grouse habitat is projected to decline under all climate and management scenarios. Although some of the impacts of climate change are likely to negatively affect rangeland condition, others may aid in the goals of restoration.

Model Limitations

Our cSTSM modeling approach has several limitations. To link MC1 with our STSMs, we in some cases represented several vegetation types with a single STSM, thus resulting in loss of ecological detail. This loss of ecological detail may have resulted in us missing important vegetation type-specific responses to changes in climate and disturbance. We have also assumed that the known dynamics of plant communities and PVTs will be relevant in the future under different climatic conditions. However, vegetation growth rates, succession rates, and species interactions are likely to change in the future with climatic changes. Relatively minor variations in species composition and structure are not represented in the STSMs; each state in the STSMs encompasses a range of compositional and structural attributes. Thus, more nuanced effects of treatments, such as the effects of thinning on structural diversity, are not reflected in the models.

Using our approach, we simulated changes in pre-defined PVTs and vegetation state classes, but could not simulate the possible reorganization of ecological communities or introduction of novel species. Climate change is expected to reorganize communities as individual species and populations respond to changing environmental conditions (Huntley 1991), but these potential novel dynamics cannot be captured using our approach. Additionally, although we incorporated changing trends in wildfire due to climate forcing into the models, we were not able to simulate direct effects of climate change on other processes, such as successional rates or invasion potential by exotic or native species. Instead we simulated changes in the extent of PVT groups and assumed that the dynamic processes in the model (excepting wildfire, which varied based on MC2 output) within each PVT will remain relatively similar under climate change.

For forested regions, we did not incorporate planting after disturbance in the cSTSMs. Planting typically occurs after stand-replacing disturbance, which is when climate-induced vegetation type changes can occur in the cSTSMs. We were uncertain about what the effects of planting would be on rates of vegetation type shifts owing to climate change. For example, would planting of climate-adapted species prevent a vegetation type shift? Or would the type shift still occur owing to climatic changes that dictate which species effectively establish at a site? We plan to address these, and other planting issues, in future model development.

It is also important to note that the cSTSM is highly influenced by interannual variability in the MC2 model runs. MC2 generates a single outcome, and fire and vegetation change projections represent a single possible future. The cSTSM incorporates many stochastic processes but is highly influenced by MC1 projections, particularly given the marked increase in wildfire.

Therefore, we emphasize that projections of extreme fire years and climate-related shifts should not be interpreted as predictions of events that are likely to occur in particular future years. Long-term trends in the cSTSM are more instructive than yearly fluctuations, although these fluctuations can represent some level of variability and uncertainty in the climate-related projections.

An additional limitation of our modeling framework is that we model all transitions, including fire, as simple probabilistic processes (not spatially explicit). For many transitions, this simplified representation is adequate. However, fire is a spatially contagious phenomenon. The area burned in a given year depends not only upon weather and fuel presence in the landscape, but also upon ignition locations and subsequent fire spread, which is influenced (and potentially constrained) by the spatial configuration of fuel loads on the landscape (Ager et al. 2010). Because our models do not represent spatial constraints to fire spread, it is likely that they will tend to overestimate fire in general, and also underestimate potential positive effects of strategically placed fuel treatments in curtailing fire spread.

It is also important to note that modeled management activities are necessarily a simplification of actual management practices in the field. For instance, in CW we assumed a 45-year harvest rotation on all private industrial lands, which does not likely represent the suite of management options applied on this land base. Additionally, we were often unable to simulate more subtle changes in management, such as thinnings in forested PVTs, where the starting and ending state class are the same (i.e. the treatment essentially has no effect in the models). In other cases, success rates of treatments are difficult to ascertain and we used a simplifying assumption, For instance, post-fire seeding success rates are extremely variable from year-to-year , in SEO. They depend on the interaction of site potential, wildfire, climate, invasive species, and management practices (McIver & Starr (2001). We used a generalized success rate based on Pyke et al. (2013) that does not reflect this variability.

CONCLUSIONS AND RECOMMENDATIONS

Southwest Oregon

For SWO, our work confirms that fire will likely remain the greatest threat to owl habitat, regardless of the details of future climate. Silvicultural activities aimed at reducing fire risk may also have negative effects on owl habitat, but these effects are minor in comparison with the impacts of fire. The management we modeled was ineffective at reducing fire within our modeling runs, but because our models do not illustrate fire spread, our results probably underestimate the potential positive effects of spatially strategic fuel treatments. Spatial representations of owl habitat through time show that the zones with abundant habitat will shift spatially through time. These shifts suggest that if it is possible to protect forests in the western portion of the region from fire, they could potentially provide abundant owl habitat within the next 40 – 50 years. This spatiotemporal pattern in owl habitat through time could be useful in setting landscape-scale priorities for fire management. For future work, we recommend refined modeling techniques to allow for the illustration of fire as a spatially explicit process, in combination with a scenario illustrating strategic fuel treatment plans.

Coastal Washington

For CW, cSTSM results suggest that significant shifts in vegetation composition will likely occur with future climate change, and current management activities (without planting) will likely facilitate, rather than prevent, vegetation shifts. Both climate change and current land management activities may also contribute to a decline in high-quality potential owl habitat in the future. These results can be used to develop adaptation options and guide future land management in CW.

Southeast Oregon

Managing habitat for the Greater sage-grouse presents many challenges, particularly as rangeland ecosystems face novel climatic conditions. Integrating the many processes that threaten sage-grouse habitat – wildfire, invasive species, climatic shifts, and their interactions – and the management activities that are used to counter these threats is essential to manage for long-term habitat conservation. Our results suggest that projected changes in climate may affect vegetation potential by increasing the amount of cool-moist shrub steppe and causing periodic increases in xeric shrub steppe, where conditions are climatically unsuitable for sage-grouse. Wildfire frequency is likely to increase under all climate change projections. Our results also suggest that rangeland condition and sage-grouse habitat in eastern Oregon are likely to decline regardless of the climatic conditions due to the prevalence of exotic grasses and juniper currently on the landscape. However, the effects of climate change on these compositional shifts are variable, and in some cases may assist the goals of management.

Future work may follow our work on incorporating climatic constraints to sage-grouse by also following a similar approach or a species distribution modeling approach to determine the likely future climatic conditions suitable for both exotic grasses and juniper. The distributions of these vegetation types are currently very tightly related to the distribution of the warm-dry and cool-moist shrub steppe PVTs, and more information about the independent effects of climate on these important vegetation types would improve our results. Using the new spatial modeling platform, ST-sim, would also improve the representation of spatially dynamic processes such as wildfire and exotic plant invasions.

MANAGEMENT APPLICATIONS AND PRODUCTS

For all three regions, our results have already been shared with stakeholders and natural resources management planners. In CW, the Washington DNR plans to use what they have learned from this project to inform future management on state lands. They also plan to use this approach to cover other regions in Washington. In SWO, results have been shared with members of the US Forest Service, and the BLM. Although these results will not be integrated in with the BLM's current resource management plan revision due to timing constraints, conversations are now underway about using the lessons learned from our results in future plans. In SEO results have been shared with the SageCon project, who will be making recommendations about strategies to accommodate the sage-grouse in management plans if it is added to the federal endangered species list in 2015.

Products include:

- Climate-informed STSMs for each of the three modeled regions. These models will be made available as Path Landscape Model databases, containing the STSMs and multiplier files needed to run the cSTSMs.

- The MC2toPath R package, developed by David Conklin and Emilie Henderson, assists users in translating climate-related shifts from MC2 into the STSMs. The package provides documentation and is archived to the CRAN repository for future users.

- Maps of projected late-century spotted owl or sage-grouse habitat for each region under all combinations of management scenarios and climate scenarios.

OUTREACH

Outreach was a key component of this project. Feedback from management practitioners and planners in public agencies, and regional collaborative groups was an essential step in the process of developing our alternative-management scenarios.

Webinars

In each region, an initial kickoff web meeting was held to introduce stakeholders and other interested managers and researchers to the project.

*A closing web meeting to present project results was conducted for CW in March of 2014.

*A closing web meeting for SWO was conducted on October 20, 2014.

A closing web meeting for SEO is planned for January, 2015.

* Recordings to be posted to our project results.

Presentations

Creutzburg MK, Henderson EB, Conklin, DR. Climate, land management and future sage-grouse habitat. Second State-and-Transition Simulation Modeling Conference, Fort Collins, CO. Sep 18, 2014.

Halofsky JE, Henderson EB. Integrating climate change into landscape planning, presented to the Northwest Ecology Group in Corvallis, OR, April 23, 2013.

Halofsky JE. Effects of climate change and land management on future vegetation and owl habitat in coastal Washington. Presented to Washington DNR, August 2013 and January 2014.

Henderson EB, Halofsky JE, Hemstrom MA, Creutzburg MK, Morzillo A. Climate, management and habitat in Southwest Oregon, presented to Society of American Foresters chapter meeting in Central Point, OR, April 16, 2013.

Henderson EB, Halofsky JE, Creutzburg MK, Salwasser J, Morzillo A, Hemstrom, MA. Planning for management in the context of clmate change: Asking the right questions. Presented to Northwest Climate Science Center's Executive Stakeholder Advisory Committee Meeting in Portland, Oregon, September 17, 2013.

Henderson EB, Fairbanks T. Finding a common language: Building science to match forest planning needs in Southwest Oregon, presented at the Pacific Northwest Climate Science Conference, Seattle, WA, September 10, 2014.

Henderson EB Can forest restoration work in the face of a changing climate? Presented to the Southern Oregon Forest Restoration Collaborative, October 15, 2014.

Publications

Submitted

Creutzburg, M.K., Grossmann, E.B. Conklin, D. Climate change and land management impact rangeland condition and sage-grouse habitat in southeastern Oregon. In review, AIMS Environmental Science special issue.

Planned

Halofsky, J.E., Halofsky, J.S., Conklin, D. Interacting effects of climate change and land management on Northern Spotted Owl habitat in coastal Washington.

Henderson E.B., Conklin, D., Morzillo, A, and Fairbanks, T. Projected changes in the spatial distribution of northern spotted owl habitat in southwestern Oregon.

Morzillo, A., Henderson, E., Csuti, B., Habitat for the Greater Sage-Grouse – interactive effects of vegetation and climate.

Synergies with other projects

Coastal Washington

In CW, much of this work was done in close collaboration with the Washington DNR. Dr. Halofsky worked closely with DNR scientists in formulating this work, partly because of the cost-share agreement between this project and the DNR. This project has helped set the stage for new work being done within their organization, across the west side of Washington State.

Southwest Oregon

Two related projects in SWO served to enhance the outreach dimension of our work. The first of these was a project aimed at providing science input to a panel convened by Oregon Governor John Kitzhaber that was tasked with developing a consensus plan for managing the O&C lands managed by the Forest Service and BLM within Oregon. This project involved non-climate modeling from STSMs, and involved extensive conversations about management desires and priorities for these lands from a variety of stakeholders, from members of the environmental community to county commissioners, to local mill owners. These conversations highlighted concerns for environmental and economic values across the landscape in the context of concerns about future fire risk.

The second of the related projects was a collaboration with Teresa Fairbanks, silviculturist for the Bureau of Land Management, based in Southern Oregon. She requested a revision of the potential vegetation map (mentioned in Technical Summary Part 1) that we use for our initial conditions. The process of revising the potential vegetation map was useful in the context of providing many discussions about forest dynamics in the potential vegetation types, and also management possibilities within them as well. Theresa was particularly helpful in providing opportunities for outreach to the Southern Oregon Forest Restoration Collaborative, and also helped to organize our webinar presentation to others within the Bureau of Land Management for our SWO work.

Southeast Oregon

In SWO, this project benefited from parallel work being done within the Institute for Natural Resources. In this case, we collaborated with the SageCon project, aimed at gathering and summarizing information about conservation of the Greater sage-grouse. Through SageCon, we built contacts that were helpful in establishing current management levels and setting management priorities. Collaboration with the SageCon project was also instrumental in mapping current sage-grouse habitat, and it facilitated conversations that led to a greater understanding of sage-grouse habitat in SEO.

In particular, work with the SageCon project led to data sharing that allowed us to explore the relationship between known grouse locations and recent climate history. This enabled the expansion of our SEO work to include a climate envelope model of sage-grouse that was integrated in with MC2, which allowed us to more realistically map and track potential sage-grouse habitat through time.

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